

FIG. 1

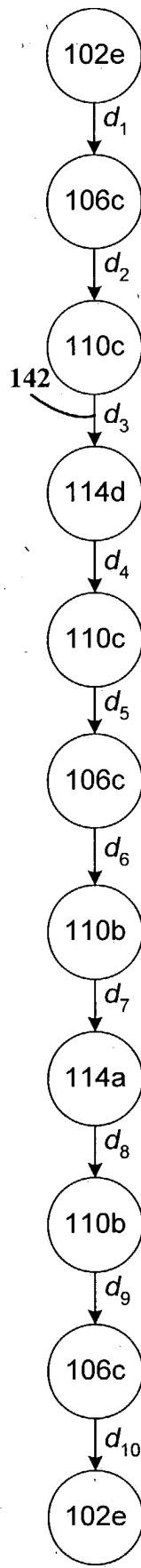


FIG. 2

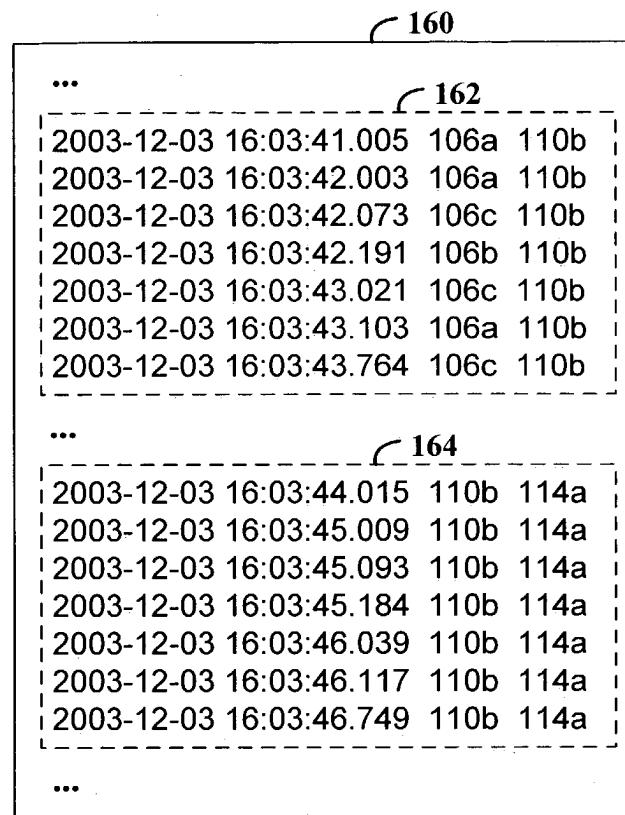


FIG. 3A

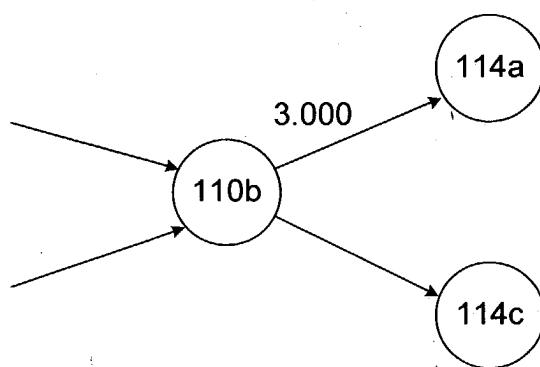


FIG. 3B

200

GENERATE GRAPH

202	Output graph := empty
204	$T_i :=$ trace of messages with source i , for every i
206	Add a new vertex $x_{initial_node}$ labeled initial_node to output graph
208	For each destination node j in $T_{initial_node}$ with destination j
210	$V :=$ messages in $T_{initial_node}$ with destination j
212	Create vertex x_j labeled j and edge $(x_{initial_node}, x_j)$ labeled 0 to output graph
214	Process_Node (j, x_j, V)

FIG. 4

250

Process_Node (j, x_j, V)

252	$O_1, \dots, O_m :=$ Find_Caused_Messages (V, T_j)
254	For $i := 1$ to m do
256	$k := O_i.node; W := O_i.messages; d := O_i.delay$
258	Add a new vertex x_k labeled k and edge (x_j, x_k) labeled d to output graph
260	Process_Node (k, x_k, W)

FIG. 5

300

Find_Caused_Messages (V, Z)

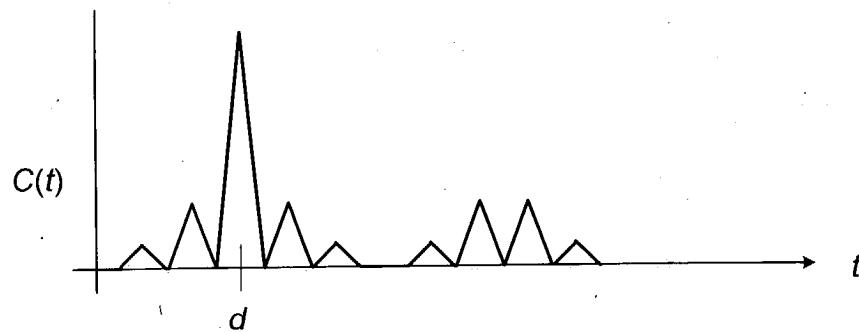
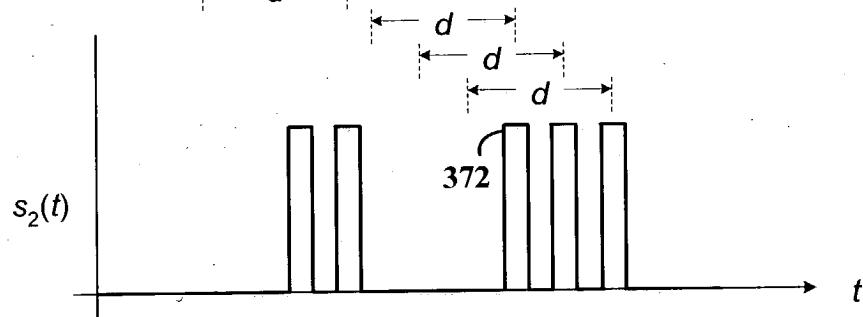
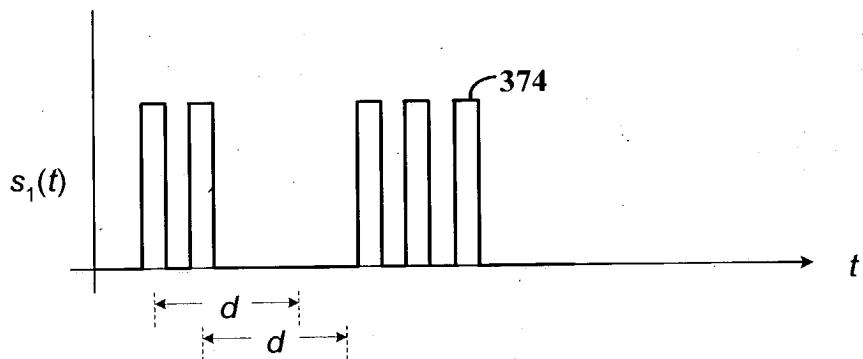
302	$i := 0$
304	$C :=$ Find_Correlation (V, Z)
306	Find positions of spikes of $C(t)$
308	For each spike position d found do
310	$Z_0 :=$ messages in Z having timestamps equal to timestamps in V shifted by d
312	For each destination node j in Z_0 do
314	$i := i + 1$
316	$O_i.node := j; O_i.delay := d; O_i.messages :=$ messages in Z_0 with destination j
318	Return O_1, O_2, \dots, O_i

FIG. 6

350

Find_Correlation (V, Z)352 $s_1(t) :=$ indicator function for V 354 $s_2(t) :=$ indicator function for Z 356 $C :=$ Correlation (s_2, s_1)358 Return C

FIG. 7



400

Find_Caused_Messages (V, Z)

402	$i := 0$
404	Nodes := Find_Related_Nodes (V, Z)
406	For each node j in Nodes do
408	$Z_0 :=$ messages in Z with destination j
410	$C :=$ Find_Correlation (V, Z_0)
412	Find positions of spikes of $C(t)$
414	For each spike position d found do
416	$Z_1 :=$ messages in Z_0 having timestamps equal to timestamps in V shifted by d
418	
420	$i := i + 1; O_i.\text{node} := j; O_i.\text{delay} := d; O_i.\text{messages} := Z_1$
422	Return O_1, O_2, \dots, O_i

FIG. 9

450

Find_Related_Nodes (V, Z)

452	Nodes := empty set
454	$C :=$ Find_Correlation (V, Z)
456	Find positions of spikes of $C(t)$
458	For each spike position d found do
460	$Z_0 :=$ messages in Z having timestamps equal to timestamps in V shifted by d
462	Nodes := union (Nodes, {nodes that appear as destinations in Z_0 })
464	Return Nodes

FIG. 10

Find_Caused_Messages (V, Z)

502	$i := 0$
504	Nodes := Find_Related_Nodes (V, Z)
506	For each node j in Nodes do
508	$Z_0 :=$ messages in Z with destination j
510	$V_0 := V$
512	While true do
514	If $\min \{ V_0 , Z_0 \} \leq \text{MinSize}$ then exit while loop
516	$C := \text{Find_Correlation} (V_0, Z_0)$
518	If maximum of $C(t)$ is not prominent then exit while loop
520	$d :=$ position of the maximum of $C(t)$
522	$Z_1 :=$ messages in Z_0 having timestamps equal to timestamps in V_0 shifted by d
524	$V_1 :=$ messages in V_0 having timestamps equal to timestamp in Z_1 shifted by $-d$
526	$i := i + 1$; $O_i.\text{node} := j$; $O_i.\text{delay} := d$; $O_i.\text{messages} := Z_1$
528	$V_0 := V_0 - V_1$; $Z_0 := Z_0 - Z_1$
530	Return O_1, O_2, \dots, O_i

FIG. 11

Find_Caused_Messages (V, Z)

552	$i := 0$
554	Nodes := Find_Related_Nodes (V, Z)
556	For each node j in Nodes do
558	$Z_0 :=$ messages in Z with destination j
560	$V_0 := V$
562	$W :=$ empty set
564	Delay_set := empty set
566	While true do
568	If $\min \{ V_0 , Z_0 \} \leq \text{MinSize}$ then exit while loop
570	$C :=$ Find_Correlation (V_0, Z_0)
572	If maximum of $C(t)$ is not prominent then exit while loop
574	$d :=$ position of the maximum of $C(t)$
576	$Z_1 :=$ messages in Z_0 having timestamps equal to timestamps in V_0 shifted by d
578	$V_1 :=$ messages in V_0 having timestamps equal to timestamps in Z_1 shifted by $-d$
580	$W :=$ union (W, Z_1)
582	Delay_set := union (Delay_set, $\{d\}$)
584	$V_0 := V_0 - V_1; Z_0 := Z_0 - Z_1$
586	$i := i + 1; O_i.\text{node} := j; O_i.\text{delay} := \text{Delay_set}; O_i.\text{messages} := W$
588	Return O_1, O_2, \dots, O_i

FIG. 12

600

Find_Related_Nodes (V, Z)

602	Nodes := empty set
604	$V_0 := V; Z_0 := Z$
606	While true do
608	If $\min \{ V_0 , Z_0 \} \leq \text{MinSize}$ then exit while loop
610	$C := \text{Find_Correlation}(V_0, Z_0)$
612	If maximum of $C(t)$ is not prominent then exit while loop
614	$d :=$ position of the maximum of $C(t)$
616	$Z_1 :=$ messages in Z_0 having timestamps equal to timestamps in V_0 shifted by d
618	$i :=$ node that is the most frequent destination in Z_1
620	Nodes := union (Nodes, { i })
622	$Z_2 :=$ messages in Z_1 with destination i
624	$V_2 :=$ messages in V_0 having timestamps equal to timestamps in Z_2 shifted by $-d$
626	$V_0 := V_0 - V_2; Z_0 := Z_0 - Z_2$
628	Return Nodes

FIG. 13